2018

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NORTHWEST CROPS & SOILS PROGRAM

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THE UNIVERSITY OF VERMONT EXTENSION

2018 CANNABIDIOL HEMP INDOOR/OUTDOOR X VARIETY REPORT

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Hemp is a non-psychoactive variety of *cannabis sativa L*. The crop is one of historical importance in the U.S. and re-emerging worldwide importance as medical providers and manufacturers seek hemp as a renewable and sustainable resource for a wide variety of consumer and industrial products. Hemp grown for all types of end-use (health supplement, fiber, and seed) contains less than 0.3% tetrahydrocannabinol (THC). Hemp varieties intended to produce a health supplement contain relatively high concentrations of a compound called cannabidiol (CBD), potentially 10-15%. CBD has purported benefits such as relief from inflammation, pain, anxiety, seizures, spasms, and other conditions. The CBD is the most concentrated in the female flower buds of the plant; however, it is also in the leaves and other plant parts as well. To grow hemp for CBD production, the crop is generally grown intensively as a specialty crop and the flowers are cultivated for maximum growth. The CBD oil is extracted and incorporated into topical products (salves, lip balm, lotion) and food and is available in pill capsules, powder form, and more, which can be found in the market today. Industrial hemp is poised to be a "new" cash crop and market opportunity for Vermont farms that is versatile and suitable as a rotation crop with other specialty crops, small grains, and grasses.

To help farmers succeed we need to develop agronomic hemp research specific to our area. We evaluated performance of four CBD hemp varieties in two types of conditions, 1) under a plastic hoop house and 2) outdoors without cover.

MATERIALS AND METHODS

Table 1. Agronomic information for the CBD hemp indoor/outdoor x variety trial 2018, Alburgh, VT.

Location	**Borderview Research Farm Alburgh, VT**
Soil type	Benson rocky silt loam, 8-15% slope
Previous crop	Buckwheat
Plant spacing (ft)	5 x 5
Planting date	6-Jul
Varieties	Boax, Carmagnola selezionata, Otto, Otto x boax
Fertilization	15-June 100 lbs N ac^{-1} 9-Aug 50 lbs N ac^{-1}
Harvest date	12-Oct and 15-Oct, outdoor plants 16-Oct, indoor plants

The CBD hemp was grown at Borderview Research Farm in Alburgh, Vermont (Table 1) to evaluate the performance of four varieties (Boax, Otto, Otto x Boax, and the industrial variety, Carmagnola selezionata) under two growing conditions (under a hoop house and outdoors). The field was fertilized with 100 lbs of N ac^{-1} just prior to laying the black plastic mulch in mid-June. Based on soil test results,

no further nutrients were required for production of hemp. After the black plastic was laid, the hoop house structure was constructed. Hemp seeds were started in a greenhouse on 14-May and the seedlings were transplanted on 6-Jul into black plastic mulch.

Image 1. CBD hemp indoor/outdoor x variety trial, Alburgh, VT, 2018.

On 9-Aug the plants were fertilized with an additional 50 lbs N ac^{-1} using organically approved fertilizers. On 11-Aug, 19-Sep, and at harvest, the plants were sampled for cannabinoid analysis performed by the Nutraceuticals Science Laboratory (Waterbury, VT). On 12-Oct and 15-Oct the outdoor plants were harvested and plant height and weight were measured. On 16-Oct the indoor plants were harvested and plant height and weight were measured. The plants were harvested by hand by using a chainsaw to cut down the entire plant. Then the plant was broken down into smaller branched sections and larger "fan" or "sun" leaves were removed, while smaller leaves were left attached since they subtend from the flower bract. Flower buds were removed by hand and by using the EZTrim Debudder (Broomfield, CO). Wet bud yield weight and unmarketable bud weight were recorded. The flower buds were then dried at 80°F until dry enough for storage without molding.

The data were analyzed using mixed model analysis using the mixed procedure of SAS (SAS Institute, 1999). Mean comparisons were made using the Least Significant Difference (LSD) procedure when the F-test was considered significant ($p<0.10$). Data was analyzed using the PROC MIXED procedure in SAS with the Tukey-Kramer adjustment, which means that each variable was analyzed with a pairwise comparison (i.e. 'variety 1' statistically outperformed 'variety 2', 'variety 2' statistically outperformed 'variety 3', etc.). Relationships between variables were analyzed using the GLM procedure.

Variations in yield and quality can occur because of variations in genetics, soil, weather, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among treatments is real or whether it might have occurred due to other variations in the field. At the bottom of each table a p-value is presented for each variable that showed statistical significance (p-value ≤ 0.10). In this case, the difference between two treatments within a column is equal to or greater than the least significant difference (LSD) value and you can be sure that for 9 out of 10 times, there is a real difference between the two treatments. In this example, hybrid 3 is significantly different from hybrid 1 but not from hybrid 2. Hybrid 2 and hybrid 3 have share the same letter 'a' next to their yield value, to indicate that these results are statistically similar. The difference between hybrid 3 and hybrid 2 is equal to 1.5, which is less than the LSD value of 2.0. This means that these hybrids did not differ in yield. The difference between hybrid 3 and hybrid 1 is equal to 3.0, which is greater than the LSD value of 2.0. This means that the yields of these hybrids were significantly different from one another. The letter 'b' next to hybrid 1's yield value shows that this value is significantly different from hybrid 2 and hybrid 3, which have the letter 'a' next to their value.

Treatment	Yield
Hybrid 1	6.0 b
Hybrid 2	7.5a
Hybrid 3	**9.0**a
LSD (p-value ≤ 0.10)	2.0

RESULTS

Seasonal precipitation and temperature were recorded with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger at Borderview Research Farm in Alburgh, VT (Table 2).

Table 2. Seasonal weather data collected in Alburgh, VT, 2018.

Alburgh, VT	July	August	September	October
Average temperature (°F)	74.1	72.8	63.4	45.8
Departure from normal	3.51	3.96	2.76	-2.36
Precipitation (inches)	2.40	3.00	3.50	3.50
Departure from normal	-1.72	-0.95	-0.16	-0.07
Growing Degree Days (base 50°F)	728	696	427	81
Departure from normal	88	115	109	81

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger. Alburgh precipitation data from August-October was provided by the NOAA data for Highgate, VT. Historical averages are for 30 years of NOAA data (1981-2010) from Burlington, VT.

The summer months were hot and dry. July through September were an average of 3.41° F warmer than historical averages and received an average of 0.94 inches less precipitation than historical averages. The tail end of the season of October received an expected amount of precipitation; however, it was cooler than historical averages. Overall, there were an accumulated 1932 Growing Degree Days (GDDs) this season, approximately 393 more than the historical average, with much of the heat throughout the summer.

Hoop house growing condition results

Table 3. Plant weight, height, yield, and quality for varieties grown under a hoop house, Alburgh, VT, 2018.

Variety	Plant weight	Plant height	Unmarketable dry matter flower yield†	Dry matter flower yield†
	lbs plant^{-1}	Cm	lbs plant^{-1}	lbs plant^{-1}
Boax	19.6 ab	179	0.007 a	2.25 a
Carmagnola selezionata	6.87 c	219	0.054 b	0.70 b
Otto	**24.2** a	217	**0.003** a	2.22 a
Otto x boax	16.6 b	168	0.005 a	2.05 a
p-value	**<0.0001**	**NS**	**0.0003**	**0.0004**
Trial mean	**18.0**	**188**	**0.0113**	**1.99**

The top performing treatment (p=0.10) is shown in **bold**.
Treatments with the same letter did not perform statistically different from one another.
NS – There was no statistical difference between treatments in a particular column (p=0.10).

The industrial hemp variety, Carmagnola selezionata clearly did not perform as well as Boax, Otto, and Otto x Boax (Table 3). The other three, typical CBD varieties, had comparable yields ranging from 2.05 – 2.25 lbs dry bud plant^{-1}. Although not statistically significant, Carmagnola selezionata was the tallest plant, which is reflective of how this variety is primarily designed for fiber production.

Outdoor growing condition results

Table 4. Plant weight, height, yield, and quality for varieties grown outdoors, Alburgh, VT, 2018.

Variety	Plant weight	Plant height	Unmarketable dry matter flower yield†	Dry matter flower yield†
	lbs plant^{-1}	Cm	lbs plant^{-1}	lbs plant^{-1}
Boax	17.1 a	147 b	0.074	2.27 a
Carmagnola selezionata	5.0 b	**192** ab	0.050	0.65 b
Otto	**22.0** a	187 a	0.000	1.69 a
Otto x boax	18.7 a	153 ab	0.011	2.04 a
p-value	**0.005**	**0.047**	**NS**	**0.001**
Trial mean	**16.8**	**161**	**0.045**	**1.92**

The top performing treatment (p=0.10) is shown in **bold**.
Treatments with the same letter did not perform statistically different from one another.
NS – There was no statistical difference between treatments in a particular column (p=0.10)

The three CBD varieties, Boax, Otto, and Otto x Boax, performed comparably for the outdoor plantings as well, while Carmagnola selezionata had much poorer yields (Table 4). The yield for the three top performing varieties ranged from 1.69 – 2.27 lbs dry flower yield plant^{-1}. Again, Carmagnola was the tallest plant, reflecting its ability to produce long, industrial hemp fibers.

At harvest, a composite flower sample from each variety and each production system (indoor versus outdoor) was analyzed for CBD percentage by the Nutraceuticals Science Laboratory (Waterbury, VT). Statistical analysis was not performed as there was only two samples for each variety. The data in Table 5 and Figure 1 indicates that CBD hemp grown in a hoop house produced higher levels of CBD concentrations. However, it should be noted that without replication it is difficult to know if these

differences are statistically significant. The variety Boax had higher levels of CBD compared to Otto, Otto x Boax, and Carmagnola. Similarly, it is unclear if the varieties are statistically different.

Table 5. Concentrations of CBD at harvest in hemp varieties grown in hoop houses or outside, 2018.

Concentrations of CBD at Harvest		
	Variety	**Total Potential CBD%**
Indoor	Boax	8.14
Outdoor	Boax	3.74
Indoor	Carmagnola	5.52
Outdoor	Carmagnola	2.37
Indoor	Otto	7.98
Outdoor	Otto	5.93
Indoor	Otto x Boax	6.60
Outdoor	Otto x Boax	5.38

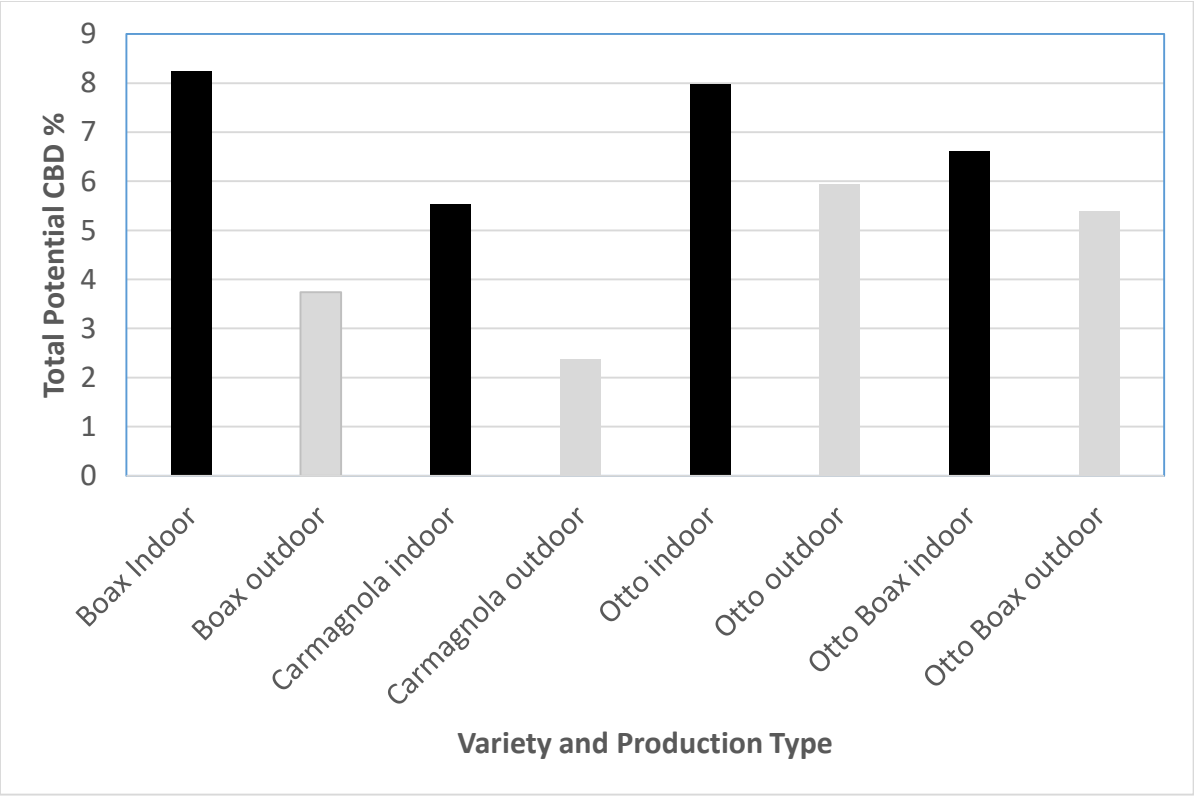

Figure 1. Concentrations of CBD in hemp varieties grown in hoop houses or outdoors, 2018.

DISCUSSION

The CBD varieties of Boax, Otto, and Otto x Boax performed well, while the industrial variety, Carmagnola selezionata had poorer yields. Pest damage was minimal. The flower buds showed *Botrytis spp.* and *Penicillium spp*. fungal sporulation as well as *Alternaria spp.* as a secondary fungus. The stems showed minimal *Alternaria spp.* and *Cladosporium spp*. damage. The primary insect pests included corn borers and aphids. Generally, damage was low and did not affect overall yields.

These plants were trellised with two layers of plastic netting and side-branches were removed from the bottom 10" of the plant in order to promote airflow. Additional pruning can be done to provide even greater airflow and potentially reduce fungal infections. Also, pruning can be done to promote more flowering branches and increase yields.

The experimental design limited the ability to run statistical analysis comparing the plants grown indoors to the plants grown outdoors. However, it is interesting to note that the average dry flower bud yield from the indoor plants was 1.99 lbs plant^{-1} and the average yield from the outdoor plants was 1.92 lbs plant^{-1}. It is surprising that there was such little difference between these yields, considering that the indoor planting had a much more protected environment. However, this past season was atypically hot. It is possible that during this past season, when it already was quite warm and there was a lack of precipitation, the hoop house condition did not provide much advantage over the outdoor condition. The indoor conditions clearly had an impact on CBD concentrations with all varieties having higher levels when grown in hoop houses versus outdoors. Further research needs to be conducted to understand why levels increase in these growing environments.

While these results provide some suggestions for plant varieties and growing conditions, it is important to remember that they represent only a one-year research trial.

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